UNITED STATES PATENT APPLICATION

FOR

AN ARRANGEMENT FOR CRANKSHAFT STRAIGHTENING

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AN ARRANGEMENT FOR CRANKSHAFT STRAIGHTENING

FIELD OF THE INVENTION

The present invention relates in general to manufacturing of a crankshaft for an internal combustion engine. More specifically, the present invention relates to an arrangement for straightening out of tolerance crankshafts.

BACKGROUND OF THE INVENTION

A typical automotive crankshaft for an internal combustion engine includes a plurality transition radii or corner areas located along various points of the crankshaft periphery such as among the transitions between counterweights, crankpins and main journals. These corner or transition radii areas are known as fillets and, under engine loads, may act as stress risers. If these stress risers are not properly treated, they can result in cracking of the crankshaft. Therefore, a hardening process is typically used for automotive crankshafts to deform these fillets and thereby increase the strength characteristics of these particular regions. As is known in the art, two commonly used hardening processes are fillet rolling and induction hardening. Although these hardening processes are necessary to increase the fatigue strength and thus the durability of the crankshaft, these processes can result in distortion of the crankshaft beyond the dimensional specifications required for today's automotive engines. More specifically, with induction hardening, residual stresses are created in the crankshaft that can result in bending and distorting the crankshaft. As a result, a certain percentage of crankshafts intended for the automotive industry are bent during the manufacturing process and are therefore not usable and scrapped.

Thus, there is a need for a process to reduce crankshaft scrap inherent in today's automotive crankshaft manufacturing processes.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides an arrangement for straightening an out of tolerance crankshaft after hardening. In accordance with one aspect of the present invention, a process is provided for straightening a bent crankshaft after hardening that includes generating data indicative of a condition of crankshaft straightness. The data is then compared to a predetermined tolerance specification to detect an out of tolerance condition. In response to a detected out of tolerance condition, data is generated indicative of location and quantity of the out of tolerance condition. The crankshaft is then selectively rehardened as a function of the data indicative of location and quantity of the out of tolerance condition to remedy the detected out of tolerance condition.

In accordance with another aspect of the present invention, a system is provided for straightening a bent crankshaft after hardening. The system includes a processing station with a hardening system and a measuring system. A controller is arranged to receive information from the measuring system and provide instructions as a function of the measurement data to the hardening system to selectively reharden the crankshaft to remedy an out of tolerance condition.

In accordance with yet another aspect of this invention, residual stresses resulting from the induction hardening process are used to selectively induction reharden the

crankshaft in strategic areas to offset bending that occurred during the typical induction hardening process of the fillet region areas.

Additional benefits and advantages of the present invention will become apparent to those skilled in the art to which this invention relates from a reading of the subsequent description of the preferred embodiment and the appended claims, taken in conjunction with the accompanying drawings.

BREIF DESCRIPTION OF THE DRAWINGS

Other aspects, features, and advantages of the present invention will become more fully apparent from the following detailed description of the preferred embodiment, the appended claims, and in the accompanying drawings in which:

Figure 1 illustrates a schematic of a system for crankshaft straightening in accordance with the present invention; and

Figure 2 illustrates a flowchart of a methodology for crankshaft straightening in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMIENT

Referring now to the drawings, Figure 1 illustrates an exemplary embodiment of a system for straightening an out of tolerance crankshaft in accordance with the present invention. The system represented in Figure 1 would typically be used in a manufacturing assembly line. Station 10 includes a fixture 15 for securing a crankshaft

in preparation for hardening and measuring. Station 10 also includes a typical crankshaft measuring apparatus 20 capable of measuring straightness and detecting bent or warped crankshafts and a typical induction hardening apparatus 30 including multi-axis electromagnetic induction hardening heads 40.

The crankshaft is induction hardened in the fillet region areas using the induction hardening apparatus 30 in accordance with known principles. The crankshaft is then measured using measuring apparatus 20. During the measuring process, measurement data 50 is generated and stored for a comparison to reference tolerance specifications. If the measurement data falls within an acceptable tolerance specification range, controller 60 allows for release of the crankshaft from station 10 to be transported to a next station in the crankshaft manufacturing line. If the measurement data does not fall within the acceptable tolerance specification range, controller 60 directs station 10 to retain the crankshaft for selective induction rehardening to remedy an out of tolerance condition.

In the selective induction rehardening process, the controller 60 sends rehardening control data 70 to the hardening system 30. The control data 70 includes predetermined rehardening parameters for use by hardening system 30 to selectively induction reharden the crankshaft to remedy the out of tolerance condition. More specifically, upon receiving measurement data indicative of location and quantity of the out of tolerance condition, controller 60 will match this measurement data to predetermined rehardening parameters correlated to the location and quantity of the out of tolerance condition.

Controller 60 contains these predetermined rehardening parameters as well as a conventional algorithm that provides for controller 60 to continuously collect and store in memory 80 empirical data results from testing, experimentation, and actual production manufacturing of out of tolerance crankshafts in the selective induction rehardening process. Thus, memory 80 is continuously populated with measurement data indicative of an out of tolerance condition, the resultant rehardening parameters selected for use in the corresponding selective rehardening process, and whether the selected rehardening parameters were successful in remedying the out of tolerance condition.

Upon selectively rehardening the crankshaft, the measurement apparatus 20 measures the crankshaft and compares it to the reference tolerance specifications. If the measurement data falls within the acceptable tolerance specification range, controller 60 allows for release of the crankshaft from station 10 to be transported to a next station in the crankshaft manufacturing line. If the measurement data does not fall within the acceptable tolerance specification range, controller 60 directs station 10 to again retain the crankshaft for selective induction rehardening to remedy the out of tolerance condition.

Referring now to Figure 2, a methodology for straightening an out of tolerance crankshaft is illustrated in accordance with the present invention. In the exemplary embodiment, step 100 involves induction hardening the crankshaft in the fillet region. Step 110 involves measuring the crankshaft after the induction hardening process. Step 120 involves comparing the measurement data of step 110 to reference tolerance

specifications. Step 130 is the next step and involves determining if the measurement data is within the reference tolerance specifications.

If the result of step 130 is "YES", the crankshaft was not distorted during the induction hardening of the fillet region in step 100 and the method continues to step 150 where the crankshaft leaves station 10 and proceeds to the next processing station.

If the result of step 130 is "NO", the crankshaft is distorted beyond the tolerance specifications and the method proceeds to step 170 where the controller determines data indicative of location and quantity of the out of tolerance condition. In step 180, memory is accessed where predetermined sets of rehardening parameters are stored. These parameters are correlated to data indicative of a particular location and quantity of out of tolerance condition. In step 190, a set of rehardening parameters correlated to the measurement data indicative of the particular location and quantity of the out of tolerance condition is identified. In step 200, the identified set for rehardening parameters is sent to the hardening system as instructions for selectively induction rehardening the crankshaft.

In step 210, the bent crankshaft is then selectively induction rehardened based on the data and instructions sent to the hardening system from step 200. The crankshaft is then remeasured in step 220 and compared to reference tolerance specifications in step 230. The method then returns to step 130 and repeats the process until the crankshaft is determined to be within the reference tolerance specifications.

The foregoing description constitutes the embodiments devised by the inventors for practicing the invention. It is apparent, however, that the invention is susceptible to modification, variation, and change that will become obvious to those skilled in the art such as using different methods and processes for hardening the crankshafts. Inasmuch as the foregoing description is intended to enable one skilled in the pertinent art to practice the invention, it should not be construed to be limited thereby but should be construed to include such aforementioned obvious variations and be limited only by the proper scope or fair meaning of the accompanying claims.